



(11) **EP 4 207 552 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.07.2023 Bulletin 2023/27

(51) International Patent Classification (IPC):
H02J 7/00^(2006.01)

(21) Application number: **23157715.6**

(52) Cooperative Patent Classification (CPC):
H02J 7/007184; H02J 7/00034; Y02E 60/10

(22) Date of filing: **24.03.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

- **LIU, Ce**
Shenzhen (CN)
- **LIU, Yanding**
Shenzhen (CN)
- **MA, Jinbo**
Shenzhen (CN)
- **WANG, Pinghua**
Shenzhen (CN)

(30) Priority: **08.04.2016 CN 201610218184**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
19211984.0 / 3 654 487
17778601.9 / 3 435 511

(74) Representative: **Grünecker Patent- und Rechtsanwälte PartG mbB Leopoldstraße 4 80802 München (DE)**

(71) Applicant: **Huawei Technologies Co., Ltd. Shenzhen, Guangdong 518129 (CN)**

(72) Inventors:
• **LIU, Xujun**
Shenzhen (CN)

Remarks:

This application was filed on 21.02.2023 as a divisional application to the application mentioned under INID code 62.

(54) **FAST CHARGING METHOD AND SYSTEM, TERMINAL, AND CHARGER**

(57) The present invention provides a fast charging method and system, a terminal, and a charger. The method includes: sending, by a terminal, instruction information to a charger connected to the terminal, so as to instruct the charger to adjust an output voltage and an output current; and converting, by the terminal, the output voltage of the charger into 1/K times the output voltage, and converting the output current of the charger into K times the output current, so that a charging circuit between two sides of the battery charges the battery with the 1/K times the output voltage and the K times the output current, where K is a conversion coefficient of a conversion unit with a fixed conversion ratio in the terminal and is a constant value, and K is any real number greater than 1. The terminal can be fast charged by implementing the fast charging method provided in the present invention.

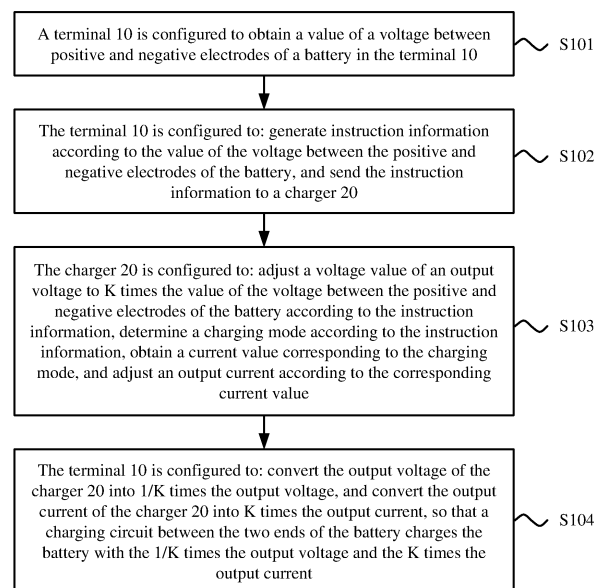


FIG. 2

EP 4 207 552 A1

Description**TECHNICAL FIELD**

[0001] The present invention relates to a charging technology, and in particular, to a fast charging method and system, and an apparatus.

BACKGROUND

[0002] With development of technologies, terminals have increasingly powerful functions. Users may work and entertain themselves by using the terminals, and a terminal has become indispensable in people's daily life. However, a battery life of a terminal is limited, and a user needs to charge the terminal constantly.

[0003] However, as a battery configured for the terminal has an increasingly large capacity and increasingly high density, it takes an increasingly long time to charge the terminal. Consequently, normal use of the user is greatly affected, and user experience is relatively poor.

SUMMARY

[0004] Embodiments of the present invention provide a fast charging method and system, a terminal, and a charger, to fast charge the terminal, thereby improving user experience.

[0005] A first aspect of the present invention discloses a terminal, and the terminal includes a detection circuit, a conversion circuit, a transmitter, a receiver, a central processing unit CPU, a charging circuit, and a battery, where

the detection circuit is configured to detect a value of a voltage between positive and negative electrodes of the battery;

the CPU is configured to generate instruction information according to the value of the voltage between the positive and negative electrodes of the battery; the transmitter is configured to send the instruction information to a charger connected to the terminal, so as to instruct the charger to adjust an output voltage and an output current;

the receiver is configured to receive the output voltage and the output current transmitted from the charger, where the receiver is electrically connected to the charger;

the conversion circuit is configured to: convert the output voltage received by the receiver into $1/K$ times the output voltage, and convert the output current received by the receiver into K times the output current, where the conversion circuit is a conversion circuit with a fixed conversion ratio, the conversion coefficient K is a constant value, and K is any real number greater than 1; and

the charging circuit is configured to charge the battery with the $1/K$ times the output voltage and the K

times the output current.

[0006] It should be noted that the conversion circuit is a buck circuit or a switch-capacitor conversion circuit.

[0007] With reference to the content described in the first aspect, further, the CPU is configured to: compare the value of the voltage between the positive and negative electrodes with a first preset threshold, to obtain a comparison result, and generate the instruction information according to the comparison result.

[0008] With reference to the content described above, it should be noted that the CPU is further configured to: when detecting that the voltage between the positive and negative electrodes of the battery reaches a second preset threshold, send a break connection notification to the receiver; and

the receiver is configured to break an electrical connection to the charger according to the break connection notification, where the first preset threshold is less than or equal to the second preset threshold.

[0009] Further, it should be noted that the terminal further includes a memory and a bus system. The processor and the memory are connected by using the bus system.

The memory is configured to store an instruction. The processor is configured to execute the instruction stored in the memory, so that the terminal is fast charged.

[0010] A second aspect of the present invention discloses a charger, and the charger includes a receiver, a voltage adjustment circuit, and a current adjustment circuit, where

the receiver is configured to receive instruction information sent by a terminal, where the instruction information includes a value of a voltage between positive and negative electrodes of a battery in the terminal and K times the value of the voltage between the positive and negative electrodes, and K is any real number greater than 1;

the voltage adjustment circuit is configured to adjust a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery; and

the current adjustment circuit is configured to: determine a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtain a current value corresponding to the charging mode, and adjust an output current according to the corresponding current value, where the charging mode includes but is not limited to a pre-charging mode, a fast charging mode, and a float charging mode.

[0011] A third aspect of the present invention discloses another charger, and the charger includes a receiver, a voltage adjustment circuit, and a current adjustment circuit, where

the receiver is configured to receive instruction information sent by a terminal, where the instruction information includes a value of a voltage between positive and negative electrodes of a battery in the terminal;

the voltage adjustment circuit is configured to adjust a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery, where K is any real number greater than 1, and K is a voltage adjustment coefficient pre-stored in the charger; and

the current adjustment circuit is configured to: determine a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtain a current value corresponding to the charging mode, and adjust an output current according to the corresponding current value, where the charging mode includes but is not limited to a pre-charging mode, a fast charging mode, and a float charging mode.

[0012] A fourth aspect of the present invention discloses a fast charging system, the system includes a terminal, a charger, and a connection cable, and the terminal is connected to the charger by using the connection cable, where

the terminal is configured to obtain a value of a voltage between positive and negative electrodes of a battery in the terminal;

the terminal is further configured to: generate instruction information according to the value of the voltage between the positive and negative electrodes of the battery, and send the instruction information to the charger;

the charger is configured to adjust a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery according to the instruction information, where K is any real number greater than 1;

the charger is further configured to: determine a charging mode according to the instruction information, obtain a current value corresponding to the charging mode, and adjust an output current according to the corresponding current value; and

the terminal is configured to: convert the output voltage of the charger into $1/K$ times the output voltage, and convert the output current of the charger into K times the output current, so that a charging circuit between the two ends of the battery charges the battery with the $1/K$ times the output voltage and the K times the output current, where K is a conversion coefficient of a conversion circuit with a fixed conversion ratio in the terminal and is a constant value.

[0013] With reference to the content described in the fourth aspect, that the terminal generates instruction information according to the value of the voltage between

the positive and negative electrodes of the battery includes: the terminal compares the value of the voltage between the positive and negative electrodes with a first preset threshold, to obtain a comparison result, and generates the instruction information according to the comparison result.

[0014] With reference to the content described in the fourth aspect, when the terminal in the system detects that the voltage between the positive and negative electrodes of the battery reaches a second preset threshold, the terminal can break an electrical connection between the terminal and the charger, or may instruct the charger to enter a sleep mode, so that the charger stops supplying power to the terminal.

[0015] It should be noted that when a battery level reaches a third preset threshold, the terminal may further actively disconnect the electrical connection to the charger, or may instruct the charger to enter a sleep mode, so that the charger stops supplying power to the terminal.

[0016] A fifth aspect of the present invention discloses a fast charging method, and the method includes:

detecting a value of a voltage between positive and negative electrodes of a battery in a terminal;

generating instruction information according to the value of the voltage between the positive and negative electrodes of the battery;

sending the instruction information to a charger connected to the terminal, so as to instruct the charger to adjust an output voltage and an output current according to the value of the voltage between the positive and negative electrodes of the battery; receiving, by the terminal, the output voltage and the output current transmitted from the charger;

converting the output voltage of the charger into $1/K$ times the output voltage, and converting the output current of the charger into K times the output current, where K is a conversion coefficient of a conversion circuit with a fixed conversion ratio in the terminal, K is a constant value, and K is any real number greater than 1; and

charging the battery with the $1/K$ times the output voltage and the K times the output current.

[0017] With reference to the content described in the fifth aspect, further, the generating, by the terminal, instruction information according to the value of the voltage between the positive and negative electrodes of the battery includes: comparing, by the terminal, the value of the voltage between the positive and negative electrodes with a first preset threshold, to obtain a comparison result, and generating the instruction information according to the comparison result.

[0018] With reference to the content described in the fifth aspect, it should be noted that when the terminal is fully charged, or a battery level reaches a third preset threshold, or the voltage reaches a second preset threshold, the terminal breaks an electrical connection between

the terminal and the charger or instructs the charger to stop charging.

[0019] A sixth aspect of the present invention discloses another fast charging method, and the method includes:

receiving, by a charger, instruction information sent by a terminal, where the instruction information includes a value of a voltage between positive and negative electrodes of a battery in the terminal; adjusting, by the charger, a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery, where K is any real number greater than 1, and K is a voltage adjustment coefficient pre-stored in the charger; and determining, by the charger, a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtaining a current value corresponding to the charging mode, and adjusting an output current according to the corresponding current value.

[0020] It may be learned from the foregoing that the technical solutions of the present invention provide a fast charging method and system, a terminal, and a charger. In the technical solutions provided in the present invention, the instruction information is sent to the charger connected to the terminal, so as to instruct the charger to adjust the output voltage and the output current. The terminal converts the output voltage of the charger into $1/K$ times the output voltage, and converts the output current of the charger into K times the output current. The conversion circuit is a conversion circuit with a fixed conversion ratio. The conversion coefficient K is a constant value, and K is any real number greater than 1. The charging circuit in the terminal charges the battery with the $1/K$ times the output voltage and the K times the output current. The terminal can be fast charged by implementing the technical solutions provided in the present invention, thereby improving user experience.

BRIEF DESCRIPTION OF DRAWINGS

[0021] To describe the technical solutions in the embodiments of the present invention more clearly, the following briefly describes the accompanying drawings required for describing the embodiments of the present invention. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. 1 is a schematic diagram of a fast charging system according to an embodiment of the present invention;

FIG. 2 is a flowchart of a fast charging method according to an embodiment of the present invention;

FIG. 2a is a flowchart of a fast charging method according to an embodiment of the present invention; FIG. 3 is a structural diagram of a fast charging system according to another embodiment of the present invention;

FIG. 3a is a diagram of a physical structure of a terminal according to another embodiment of the present invention;

FIG. 4 is a diagram of a buck circuit according to an embodiment of the present invention;

FIG. 5 is a circuit diagram of a switch-capacitor converter according to another embodiment of the present invention;

FIG. 6 is a flowchart of a fast charging method according to another embodiment of the present invention;

FIG. 7 is a flowchart of a fast charging method according to another embodiment of the present invention;

FIG. 8 is a flowchart of a fast charging method according to another embodiment of the present invention; and

FIG. 9 is a schematic diagram of pulse current charging according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0022] The following clearly describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are a part rather than all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0023] As terminals become increasingly powerful, people become more dependent on the terminals, and even take the terminals at any time. People may communicate, work, entertain themselves, and do the like by using the terminals, and a terminal plays an important role in daily life. An ensuing problem is that when a large quantity of applications simultaneously run for a long time, power of a terminal is consumed quickly. In addition, because a battery configured for the terminal has a large capacity and high density, a charging speed is relatively slow. Consequently, use of a user is greatly affected, and user experience is reduced.

[0024] The present invention provides a fast charging system (FCS for short). The FCS can implement fast charging. For a detailed schematic diagram of the FCS, refer to FIG. 1. The system includes a terminal 10, a charger 20, and a connection cable 30. The terminal 10 is connected to the charger 20 by using the connection cable 30.

[0025] It should be noted that as shown in FIG. 2, the

system implements fast charging by using the following procedure.

[0026] S101. The terminal 10 is configured to obtain a value of a voltage between positive and negative electrodes of a battery in the terminal 10.

[0027] There are many manners of obtaining the voltage value of the battery. For example, a detection circuit may be formed by connecting the two ends of the battery, so that the value of the voltage between the positive and negative electrodes of the battery can be obtained at any time.

[0028] The terminal may be an electronic device such as a mobile phone, a tablet computer, an intelligent wearable device, or a computer.

[0029] The battery in the terminal is usually a lithium-ion battery. A type of the battery is not limited herein.

[0030] S102. The terminal 10 is configured to: generate instruction information according to the value of the voltage between the positive and negative electrodes of the battery, and send the instruction information to the charger 20.

[0031] It may be understood that the connection cable between the terminal 10 and the charger 20 has a communication function, and may be used for transferring information between the terminal 10 and the charger 20.

[0032] It may be understood that in addition to the connection cable, there are communication lines (that is, a line D+ and a line D-) between the terminal 10 and the charger 20. Direct current voltages with various amplitudes are separately applied to the lines D+ and D-, and multiple status combinations are generated. Each state may represent one signal. For example, (0 V, 0 V) represents that a charging current is 0 A. (0 V, 0.4 V) represents 0.5 A. (0.4 V, 0.4 V) represents 2 A. (2.8 V, 2.8 V) represents that charging stops. Optionally, PWM voltages with a duty cycle are separately applied to the lines D+ and D-, and a pulse width is used to represent a signal.

[0033] It may be understood that, alternatively, communication may be performed between the terminal 10 and the charger 20 in a wireless manner.

[0034] S103. The charger 20 is configured to: adjust a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery according to the instruction information, determine a charging mode according to the instruction information, obtain a current value corresponding to the charging mode, and adjust an output current according to the corresponding current value, where K is any real number greater than 1.

[0035] It may be understood that the instruction information includes the value V1 of the voltage between the positive and negative electrodes of the battery and V2, that is, K times the value of the voltage between the positive and negative electrodes of the battery. Because K is greater than 1, V2 is greater than V1. The charger directly adjusts the output voltage to V2, that is, K times the value of the voltage between the positive and negative electrodes of the battery.

[0036] It may be understood that the instruction information includes the value V1 of the voltage between the positive and negative electrodes of the battery, and a voltage adjustment coefficient K is pre-stored in the charger. Therefore, the charger directly adjusts the output voltage to V2, that is, K times the value of the voltage between the positive and negative electrodes of the battery. The charger determines the charging mode according to the value V1 of the voltage between the positive and negative electrodes of the battery, then obtains the current value corresponding to the charging mode from a memory of the terminal, and adjusts the output current according to the corresponding current value.

[0037] S104. The terminal 10 is configured to: convert the output voltage of the charger 20 into 1/K times the output voltage, and convert the output current of the charger 20 into K times the output current, so that a charging circuit between the two ends of the battery charges the battery with the 1/K times the output voltage and the K times the output current, where K is a conversion coefficient of a conversion circuit with a fixed conversion ratio in the terminal and is a constant value.

[0038] It may be understood that, in a process of charging the terminal 10, the voltage between the positive and negative electrodes of the battery may be obtained at any time, and a charging current may be adjusted according to the value of the voltage. For example, the terminal 10 compares the obtained voltage value with a first preset threshold, obtains a comparison result, and generates the instruction information according to the comparison result, to instruct the charger to adjust the current. In addition, it should be noted that when the terminal 10 detects that the voltage between the positive and negative electrodes of the battery reaches a second preset threshold, the terminal breaks an electrical connection between the terminal and the charger. The first preset threshold is less than or equal to the second preset threshold.

[0039] It may be understood that, the terminal in the FCS provided in this embodiment of the present invention uses a direct current/direct current (DC/DC) conversion manner with a fixed conversion ratio, works with a fixed maximum duty cycle, and continuously adjusts the output voltage and the output current of the charger based on a real-time voltage feedback of the battery, thereby effectively improving charging efficiency of the entire FCS and shortening a fast charging time.

[0040] As shown in FIG. 2a, in another embodiment of the present invention, a specific fast charging method is provided. The method may be applied to the FCS described in FIG. 1. It is assumed that 3 V is a lower limit threshold of a fast charging voltage, 4.15 V is an upper limit threshold of the fast charging voltage, and a conversion coefficient K of a DC/DC conversion module with a fixed conversion ratio in a terminal is equal to 2, and the method includes the following steps.

[0041] S201. The terminal is connected to a charger by using a connection cable.

[0042] S202. The terminal detects a value of a voltage between positive and negative electrodes of a battery in the terminal, and sends the voltage value to the charger by using the connection cable.

[0043] S203. The charger determines whether the voltage value is greater than 3 V.

[0044] S204. When the voltage value is less than 3 V, the charger enables a pre-charging mode.

[0045] The pre-charging mode is as follows: When the voltage value is less than 3 V, the charger performs pre-charging with a small current, a selected pre-charging current is 0.2 C (a current range may be 0.05 C to 0.5 C). A current value of the pre-charging current may be preset at delivery, or may be manually set by a user within the current range. It should be noted that if a capacity of the battery is 3 Ah, 1 C represents 3 A.

[0046] S205. When the voltage value falls within a range of 3.0 V to 4.15 V, the charger enables a fast charging mode.

[0047] The fast charging mode is as follows: When the value of the voltage between the positive and negative electrodes of the battery falls within the range of 3.0 V to 4.15 V, the charger performs fast charging. The charger adjusts a specified charging current of 2.0 C (a current range may be 0.5 C to 10 C). A current value of the current may be preset at delivery, or may be manually set by a user within the current range. In this fast charging phase, an output voltage of the charger is V1, and V1 is specifically determined according to a real-time feedback voltage V_{battery} of the battery. Specifically, $V1 = V_{\text{battery}} \times 2$. An output current of the charger is 2.0 C. A mobile phone side converts the output voltage V1 and the output current I1 of the charger by using the DC/DC conversion module with a fixed conversion ratio. An output voltage V2 of the conversion circuit $= V1/2 = V_{\text{battery}}$ and an output current $I2 = 2.0 \text{ C} \times 2 = 4.0 \text{ C}$.

[0048] S206. When the voltage value is greater than 4.15 V, the charger performs float charging.

[0049] The float charging may be understood as charging with a constant voltage or a small current.

[0050] When the feedback voltage of the battery exceeds 4.15 V, the charger adjusts the charging current. A charging current range is 0.01 C to 1.0 C. A current value of the current may be preset at delivery, or may be manually set by a user within the current range.

[0051] The following describes in detail structures of a terminal and a charger in an FCS according to an embodiment of the present invention with reference to FIG. 3. As shown in FIG. 3, a terminal 10 in the FCS includes a detection circuit 110, a conversion circuit 120, a transmitter 130, a battery 140, a Central Processing Unit (CPU) 150, a charging circuit 160, and a receiver 170.

[0052] The detection circuit 110 is configured to detect a value of a voltage between positive and negative electrodes of the battery 140.

[0053] For example, as shown in FIG. 3a, in a specific detection circuit for detecting a voltage of a battery in a mobile phone, a switch Qb is serially connected to the

battery. During charging, the switch Qb is turned on. When the voltage of the battery is being detected, the switch Qb is turned off. Both a charging current and a discharging current are 0, so that voltage drops of the cable and internal resistance drop to the minimum. Qd is turned on at the same time. The voltage of the battery is divided by R1R2 and sent to a back-end analog-to-digital converter or a comparator, to obtain the voltage of the battery.

[0054] The CPU 150 is configured to generate instruction information according to the value of the voltage between the positive and negative electrodes of the battery 140.

[0055] The transmitter 130 is configured to send the instruction information to a charger 20 connected to the terminal 10, so as to instruct the charger 20 to adjust an output voltage and an output current.

[0056] The receiver 170 is configured to receive the output voltage and the output current transmitted from the charger, where the receiver is electrically connected to the charger.

[0057] The conversion circuit 120 is configured to: convert the output voltage received by the receiver 170 into 1/K times the output voltage, and convert the output current received by the receiver 170 into K times the output current, where the conversion circuit 120 is a conversion circuit with a fixed conversion ratio, the conversion coefficient K is a constant value, and K is any real number greater than 1.

[0058] The charging circuit 160 is configured to charge the battery 140 with the 1/K times the output voltage and the K times the output current.

[0059] Optionally, the conversion circuit is a buck circuit or a switch-capacitor conversion circuit.

[0060] For example, as shown in FIG. 4, the conversion circuit 120 uses a buck manner with a fixed duty cycle. In a buck with a fixed duty cycle, switching transistors Q1 and Q2 form a bridge arm. Drive signals V1 and V2 drive Q1 and Q2 to be alternatively turned on, to convert a direct current voltage V_{in} into a pulse voltage with a fixed duty cycle, and implement a voltage drop with a conversion coefficient of K. A direct current voltage V_{out} is output after filtering of an inductor L3, and $V_{\text{out}} = V_{\text{in}}/K$. The duty cycle is fixed at a maximum value, to implement efficient charging. In addition, in the buck manner with a fixed duty cycle, multiple bucks may be connected in parallel according to a sequence of phases to form a multiphase buck.

[0061] For example, as shown in FIG. 5, the DC/DC conversion module may be further a switch-capacitor converter. Four switching transistors in the switch-capacitor converter are connected in series. A capacitor C7 is connected between a midpoint of Q1Q2 and a midpoint of Q3Q4. V2 to V5 are drivers of the switching transistors. V2 and V5 are complementary. V3 and V4 are complementary. A 2:1 switch-capacitor converter may drop an input voltage to a half of the input voltage at a fixed ratio of 2:1. After conversion performed on V_{in} by the conver-

sion circuit, an output voltage $V_{out} \approx V_{in}/2$. Switch-capacitor conversion does not need an inductor, and a loss can be significantly reduced. Therefore, conversion efficiency can be significantly improved, and a larger charging current can be implemented.

[0062] It may be understood that, in a process of charging the terminal 10, the voltage of the battery 140 is continuously increased, and therefore it is required to continuously instruct the charger to adjust an output current. Therefore, the CPU 150 is further configured to: compare the voltage value obtained by the detection circuit 110 with a first preset threshold, to obtain a comparison result, and generate the instruction information according to the comparison result. The transmitter 130 is configured to send the instruction information to the charger. The instruction information is used to instruct the charger to adjust the output current. For example, the first preset threshold is 3 V. The detection circuit 110 detects the value of the voltage between the positive and negative electrodes of the battery, and the detected value of the voltage between the positive and negative electrodes is 2.5 V. The CPU 150 determines that the value of the voltage between the positive and negative electrodes is less than the first preset threshold, and instructs the charger to perform charging in a slow charging manner. If the detected voltage value is 3.5 V, the CPU 150 determines that the value of the voltage between the positive and negative electrodes is greater than the first preset threshold, and instructs the charger to perform charging in a fast charging manner. The slow charging manner has a corresponding output current (which may be a current value, or may be a value range). The fast charging manner also has a corresponding output current (which may be a current value, or may be a value range).

[0063] Further, it should be noted that, an electricity quantity of the battery 140 is continuously accumulated as time goes by, and then the detection circuit 110 detects a battery level of the battery 140, and determines whether the battery 140 is fully charged. Therefore, the CPU 150 is further configured to: when detecting that the voltage of the battery 140 reaches a second preset threshold, send a break connection notification to the receiver 170. The receiver 170 is configured to break an electrical connection to the charger according to the break connection notification. Optionally, when detecting that the voltage of the battery 140 reaches the second preset threshold, the CPU 150 may further instruct the charger 20 to enter a sleep mode, so that the charger stops supplying power.

[0064] The detection circuit 110 may be further configured to detect a current of the battery 140 and a state of charge of the battery. When the current is excessively large or charges are consumed excessively quickly, the detection circuit 110 gives a notification on an interface of the terminal.

[0065] It should be noted that in this embodiment of the present invention, the terminal 10 may further include a memory 180 and a bus system. The CPU 150 and the memory are connected by using the bus system. The

memory is configured to store an instruction. The processor is configured to execute the instruction stored in the memory, so that the terminal 10 performs the fast charging method. It should be understood that in this embodiment of the present invention, the CPU 150 may be another general-purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA) or another programmable logic device, a discrete gate or a transistor logic device, a discrete hardware component, or the like. The general-purpose processor may be a microprocessor, or the processor may be any conventional processor. The memory may include a read-only memory and a random access memory, and provide an instruction and data for the CPU. A part of the memory may further include a nonvolatile random access memory. For example, the memory may further store information about a device type. In addition to a data bus, the bus system may include a power bus, a control bus, a status signal bus, and the like.

[0066] As shown in FIG. 3, the charger 20 in the FCS includes a receiver 210, a voltage adjustment circuit 220, and a current adjustment circuit 230.

[0067] The receiver 210 is configured to receive instruction information sent by the terminal 10, where the instruction information includes a value of a voltage between positive and negative electrodes of the battery in the terminal 10 and K times the value of the voltage between the positive and negative electrodes, and K is any real number greater than 1.

[0068] The voltage adjustment circuit 220 is configured to adjust a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery.

[0069] The current adjustment circuit 230 is configured to: determine a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtain a current value corresponding to the charging mode, and adjust an output current according to the corresponding current value.

[0070] Optionally, the charger is connected to a power supply. Therefore, the charger includes an alternating current/direct current conversion module, so as to convert an alternating current provided by the power supply into a direct current.

[0071] It may be understood that, in the present invention, the terminal uses a DC/DC conversion manner with a fixed conversion ratio, works with a fixed duty cycle, and continuously adjusts the output voltage and the output current of the charger based on a real-time voltage feedback of the battery. Conversion efficiency of the DC/DC conversion manner is higher, so that a charging current output to the battery on a mobile phone side can be larger, and charging efficiency of the entire FCS is effectively improved, thereby effectively shortening a fast charging time.

[0072] For the fast charging system in FIG. 1, an embodiment of the present invention further provides a

charging method. The method includes a terminal side method and a charger side method.

[0073] As shown in FIG. 6, the fast charging method on a terminal side includes the following steps:

S301. A terminal 10 detects a value of a voltage between positive and negative electrodes of a battery in the terminal 10.

S302. The terminal 10 generates instruction information according to the value of the voltage between the positive and negative electrodes of the battery, and sends the instruction information to a charger connected to the terminal 10, so as to instruct the charger 20 to adjust an output voltage and an output current.

S303. The terminal 10 converts the output voltage of the charger into $1/K$ times the output voltage, and converts the output current of the charger 20 into K times the output current, where K is a conversion coefficient of a conversion circuit with a fixed conversion ratio in the terminal 10, K is a constant value, and K is any real number greater than 1.

S304. The terminal 10 charges the battery with the $1/K$ times the output voltage and the K times the output current.

[0074] It may be understood that in a fast charging process, the voltage between the positive and negative electrodes of the battery in the terminal 10 continuously changes, and the battery needs to be charged with different currents according to different voltage ranges of the battery.

[0075] Therefore, that the terminal generates the instruction information according to the value of the voltage between the positive and negative electrodes of the battery includes the following:

[0076] The terminal compares the value of the voltage between the positive and negative electrodes with a first preset threshold, to obtain a comparison result, and generates the instruction information according to the comparison result. Further, it should be noted that the terminal 10 needs to continuously detect whether the battery is fully charged, and when the battery is fully charged, needs to instruct the charger 20 to stop charging or disconnect an electrical connection to the charger 20. Optionally, the terminal 10 may detect whether the voltage between the positive and negative electrodes of the battery reaches a second preset threshold, and when detecting that the voltage between the positive and negative electrodes of the battery reaches the second preset threshold, disconnects an electrical connection between the terminal and the charger.

[0077] As shown in FIG. 7, the fast charging method on a charger 20 side includes the following steps:

S401. A charger 20 receives instruction information sent by a terminal, where the instruction information includes a value of a voltage between positive and

negative electrodes of a battery in the terminal 10. S402. The charger 20 adjusts a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery, where K is any real number greater than 1, and K is a voltage adjustment coefficient pre-stored in the charger.

S403. The charger 20 determines a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtains a current value corresponding to the charging mode, and adjusts an output current according to the corresponding current value.

[0078] As shown in FIG. 8, the fast charging method on a charger 20 side further includes the following steps:

S501. A charger 20 receives instruction information sent by a terminal 10, where the instruction information includes a value of a voltage between positive and negative electrodes of a battery in the terminal 10 and K times the value of the voltage between the positive and negative electrodes, and K is any real number greater than 1.

S502. The charger 20 adjusts a voltage value of an output voltage to K times the value of the voltage between the positive and negative electrodes of the battery.

S503. The charger 20 determines a charging mode according to the value of the voltage between the positive and negative electrodes of the battery, obtains a current value corresponding to the charging mode, and adjusts an output current according to the corresponding current value.

[0079] It may be understood that, in the present invention, the terminal uses a DC/DC conversion manner with a fixed conversion ratio, works with a fixed duty cycle, and continuously adjusts the output voltage and the output current of the charger based on a real-time voltage feedback of the battery. Conversion efficiency of the DC/DC conversion manner is higher, so that a charging current output to the battery on a mobile phone side can be larger, and charging efficiency of the entire FCS is effectively improved, thereby shortening a fast charging time.

[0080] In another fast charging embodiment provided in the present invention, a charger and a mobile phone are used as an example for description.

- (1) The charger is connected to the mobile phone.
- (2) A voltage of a battery is detected in the mobile phone to obtain a voltage value V , and $2V$ is sent to the charger by using a data cable, or may be sent to the charger by using a wireless network (it is assumed that a conversion coefficient K of a conversion circuit with a fixed conversion ratio in the mobile phone is equal to 2).

(3) After receiving the voltage information, the charger first adjusts an output voltage to $2V$ or $2V \times (1+x\%)$, to prevent the battery from back feeding a current towards an input end. A value range of x is 1 to 10 (including 1 and 10).

(4) The charger instructs the mobile phone to enable charging.

(5) The charger determines whether fast charging can be performed. For example, when the voltage of the battery is only 2.7 V , the charger adjusts a current to a small current, to perform pre-charging with a small current until the voltage of the battery reaches 3 V . Then, the charger adjusts the current to 4 A , and the terminal is fast charged with 8 A according to the conversion coefficient.

(6) In a process of charging the mobile phone, the voltage of the battery is detected at an interval of a preset time, and it is determined, according to the voltage of the battery, whether to instruct the charger to adjust a value of a current. At the moment of detecting the voltage of the battery, charging may be stopped, or a charging current may be reduced.

For example, when the voltage of the battery is close to 4.2 V (for example, reaches 4.15 V), the mobile phone instructs the charger to enter a small current charging state or a constant voltage charging state. When the voltage reaches 4.2 V after charging, charging stops. In a fast charging process, the current may decrease as the voltage of the battery increases. The current may decrease in a stepped manner or a continuous manner. In the charging process, in addition to a consecutive direct current, an inconsecutive pulse current may be used for charging.

(7) After charging stops, one of the following states may be entered:

A. The charger no longer supplies a current to the mobile phone. A working current of the mobile phone is supplied by the battery. In this state, when the voltage of the battery reaches a value after discharging, for example, the voltage drops down to 4.1 V , charging is recovered.

B. The charger supplies a working current to the mobile phone, but a path used for charging the battery is cut off, and does not supply a charging current to the battery. In this case, the battery does not supply power to the mobile phone, and is always in a fully charged state until a connection between the charger and the mobile phone is broken.

[0081] In another fast charging embodiment of the present invention, a specific pulse current charging implementation is provided. As shown in FIG. 9, an upper part of FIG. 9 is a pulse current waveform, and a lower part of FIG. 9 is a waveform when a voltage of a battery becomes higher after charging. A horizontal coordinate

represents a time, and a vertical coordinate represents a charging current.

[0082] During a period of T_{on} , the charging current is a relatively large value, and the voltage of the battery rises.

[0083] During a period of T_{off} , the current is 0 or a relatively small value, and the voltage of the battery drops down. During the period of T_{off} , the voltage of the battery may be detected.

[0084] A current value during the period of T_{on} may also vary according to the voltage of the battery. For example, at first, the voltage of the battery is 3 V , and a current during the period of T_{on} is 8 A . When the voltage of the battery reaches 4.0 V , the current is adjusted to a small value: 6 A . When the voltage of the battery reaches 4.15 V , the current is adjusted to a small value: 3 A , until the battery is fully charged.

[0085] A value of the period of T_{off} may change. For example, when the voltage of the battery reaches 4.2 V , the period of T_{off} gets longer as a battery level gets closer to a full battery level. The process in which the period of T_{off} gets longer may be implemented by detecting the voltage of the battery.

[0086] For example, after a charging pulse, the voltage of the battery necessarily slightly exceeds 4.2 V . Then, after the pulse ends, the voltage of the battery starts to drop down, and when the voltage drops down to 4.18 V , another pulse comes. A higher battery level necessarily leads to a longer time for the voltage to drop down to 4.18 V . When the time is long enough, it is considered that the battery is fully charged, and an electrical connection between the terminal and the charger can be broken.

[0087] A person of ordinary skill in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of the present invention.

[0088] It may be clearly understood by a person skilled in the art that, for the purpose of convenient and brief description, for a detailed working process of the foregoing system, apparatus, and unit, reference may be made to a corresponding process in the foregoing method embodiments, and details are not described herein again.

[0089] In the several embodiments provided in this application, it should be understood that the disclosed system, apparatus, and method may be implemented in other manners. For example, the described apparatus embodiment is merely an example. For example, the unit division is merely logical function division and may be

other division in actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented by using some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

[0090] The units described as separate parts may or may not be physically separate, and parts displayed as units may or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected according to actual requirements to achieve the objectives of the solutions of the embodiments.

[0091] In addition, function units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units are integrated into one unit.

[0092] When the functions are implemented in the form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the present invention essentially, or the part contributing to the prior art, or some of the technical solutions may be implemented in a form of a software product. The software product is stored in a storage medium, and includes several instructions for instructing a computer device (which may be a personal computer, a server, or a network device) to perform all or some of the steps of the methods described in the embodiments of the present invention. The foregoing storage medium includes: any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (ROM, Read-Only Memory), a random access memory (RAM, Random Access Memory), a magnetic disk, or an optical disc.

[0093] The foregoing descriptions are merely specific implementations of the present invention, but are not intended to limit the protection scope of the present invention. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in the present invention shall fall within the protection scope of the present invention. Therefore, the protection scope of the present invention shall be subject to the protection scope of the claims.

Claims

1. A charger comprising a receiver, a voltage adjustment circuit, wherein

the receiver is configured to receive instruction information from an electronic device, the instruction information comprising a value of a voltage between positive and negative elec-

trodes of a battery in the electronic device; the voltage adjustment circuit is configured to adjust a voltage value of an output voltage to at least K times the value of the voltage between the positive and negative electrodes of the battery, the K being any real number greater than one.

2. The charger of claim 1, wherein the charger comprising a current adjustment circuit, the current adjustment circuit is configured to: determine a charging mode according to the value of the voltage between the positive and negative electrodes of the battery.

3. The charger of claim 2, wherein the current adjustment circuit is further configured to: obtain a current value corresponding to the charging mode.

4. The charger of claim 3, wherein the current adjustment circuit is configured to: adjust an output current according to the charging mode, wherein the charging mode is according to the value of the voltage between the positive and negative electrodes of the battery.

5. The charger of claim 4, wherein the charging mode comprising a pre-charging mode, a fast charging mode, and a float charging mode.

6. A fast charging method, comprising:
 detecting, by an electronic device, a value of a voltage between positive and negative electrodes of a battery in the electronic device;
 generating, by the electronic device, instruction information according to the value of the voltage between the positive and negative electrodes of the battery;
 adjusting, by a charger, an output voltage and an output current according to the instruction information from the electronic device;
 receiving, by the electronic device, the output voltage and the output current transmitted from the charger;
 converting, by the electronic device, the output voltage of the charger into 1/K times the output voltage; the K being a conversion coefficient of a conversion circuit with a fixed conversion ratio in the electronic device, and K being any real number greater than one; and
 charging, by the electronic device, the battery with the 1/K times the output voltage.

7. The method of claim 6, wherein the method further comprising:
 converting, by the electronic device, the output cur-

rent of the charger into K times the output current.

8. The method according to claim 6 or 7, wherein generating the instruction information comprises: generating, by the electronic device, the instruction information in response to obtaining a charging mode of the charger. 5

9. The method according to claim 6 to 8, wherein generating the instruction information comprises: 10

comparing, by the electronic device, the value of the voltage between the positive and negative electrodes with a first threshold to obtain a comparison result; and 15
generating, by the electronic device, the instruction information according to the comparison result.

10. The method of claim 9, further comprising: 20

detecting, by the electronic device, whether the voltage between the positive and negative electrodes of the battery reaches a second threshold; and 25
breaking, by the electronic device, an electrical coupling between the electronic device and the charger when the voltage between the positive and negative electrodes of the battery reaches the second threshold. 30

11. A fast charging system, comprising:

a charger; and
an electronic device coupled to the charger and configured to: 35

generate instruction information according to the value of the voltage between the positive and negative electrodes of the battery; 40
and
send the instruction information to the charger,

the charger being configured to: 45

adjust a voltage value of an output voltage;
determine a charging mode according to the instruction information;
and 50

the terminal being further configured to:
convert the output voltage of the charger into 1/K times the output voltage to enable a charging circuit between two ends of the battery to charge the battery with the 1/K times the output voltage, the K being a conversion coefficient of a conversion circuit with a fixed conversion ratio in the 55

terminal, K is any real number greater than one.

12. The fast charging system of claim 11, wherein the voltage value of the output voltage of the charger is at least K times the value of the voltage between the positive and negative electrodes of the battery according to the instruction information.

13. The fast charging system according to claim 11 or 12, wherein the charger is further configured to obtain a current value corresponding to the charging mode; and adjust an output current according to the corresponding current value.

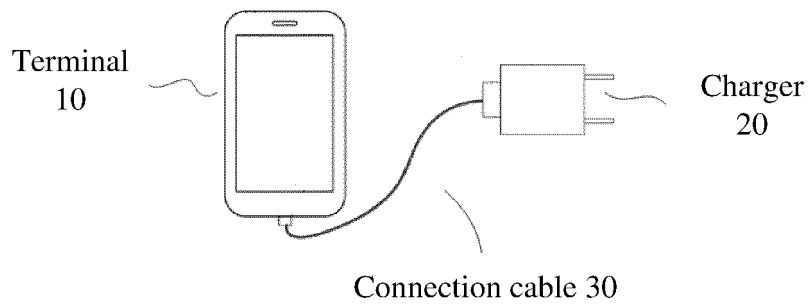


FIG. 1

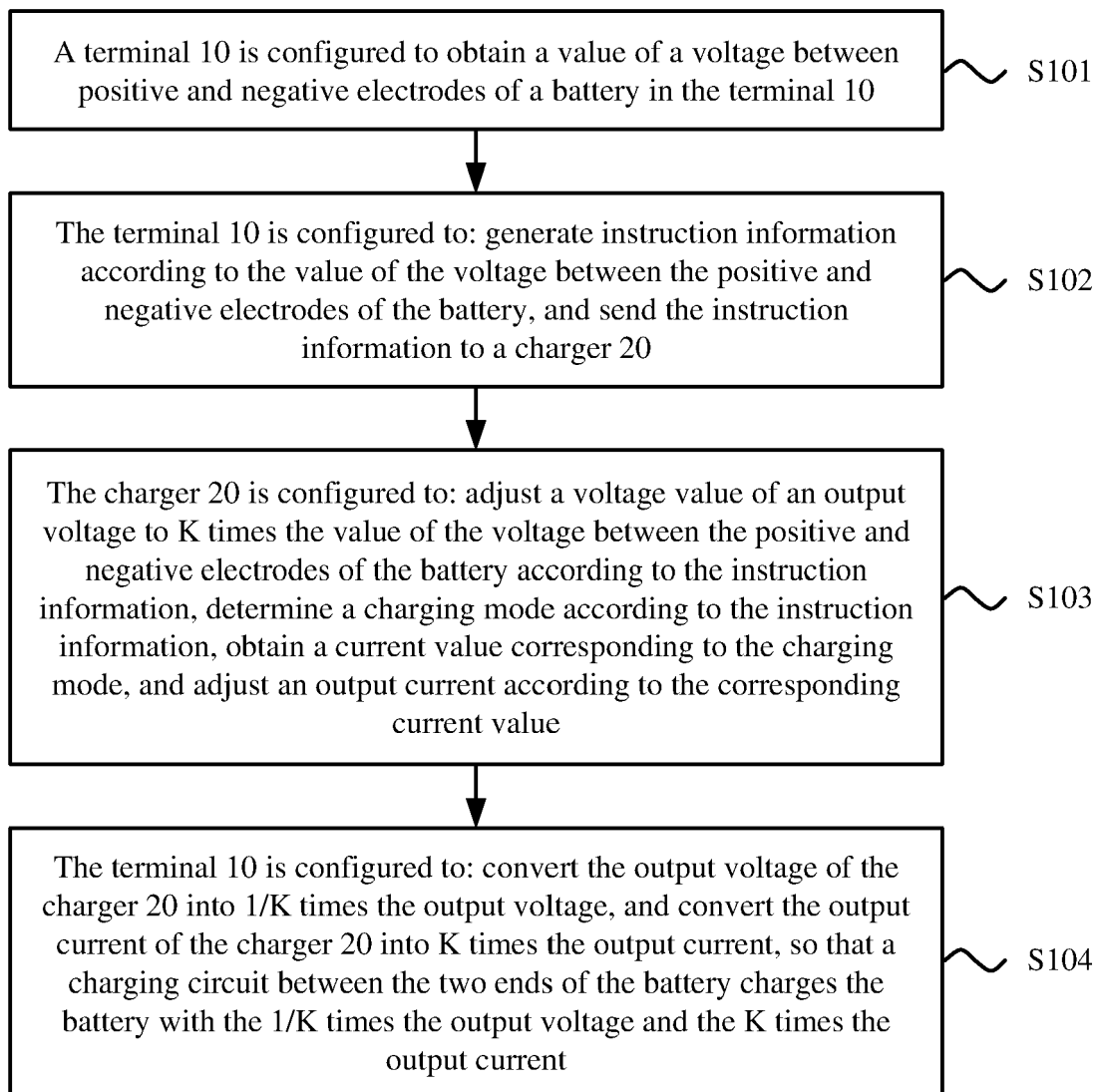


FIG. 2

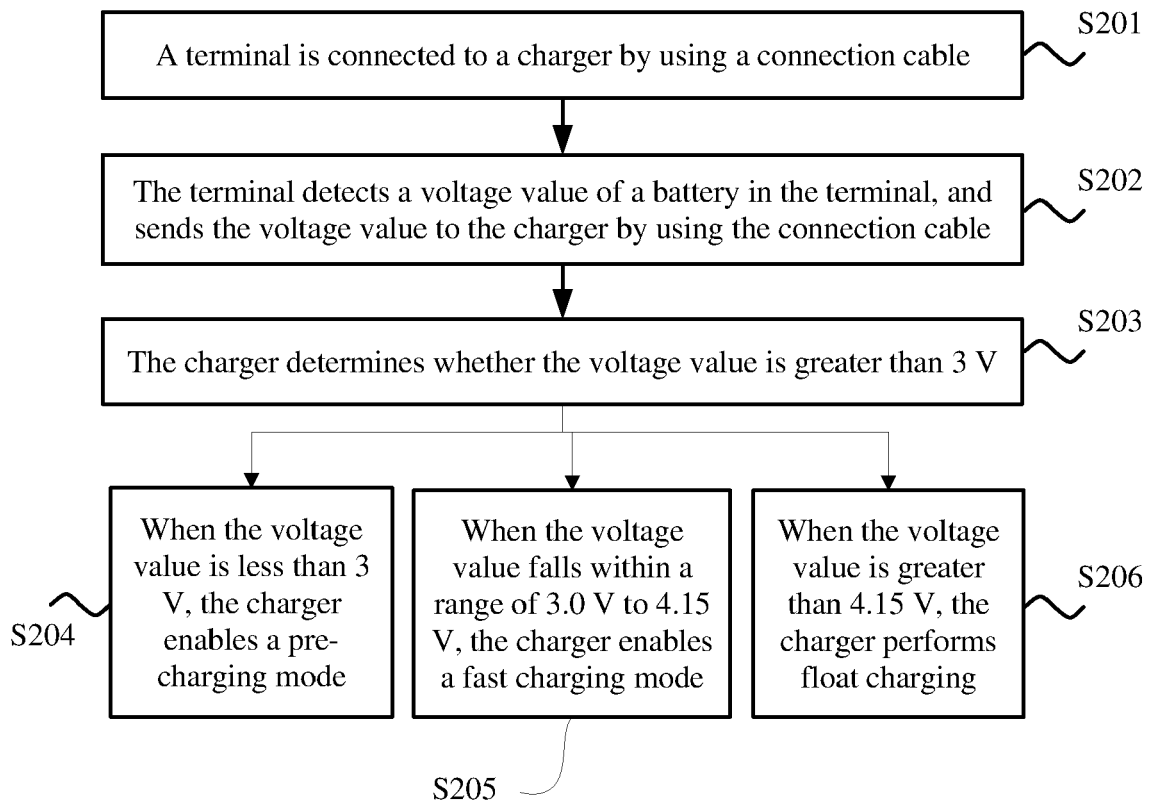


FIG. 2a

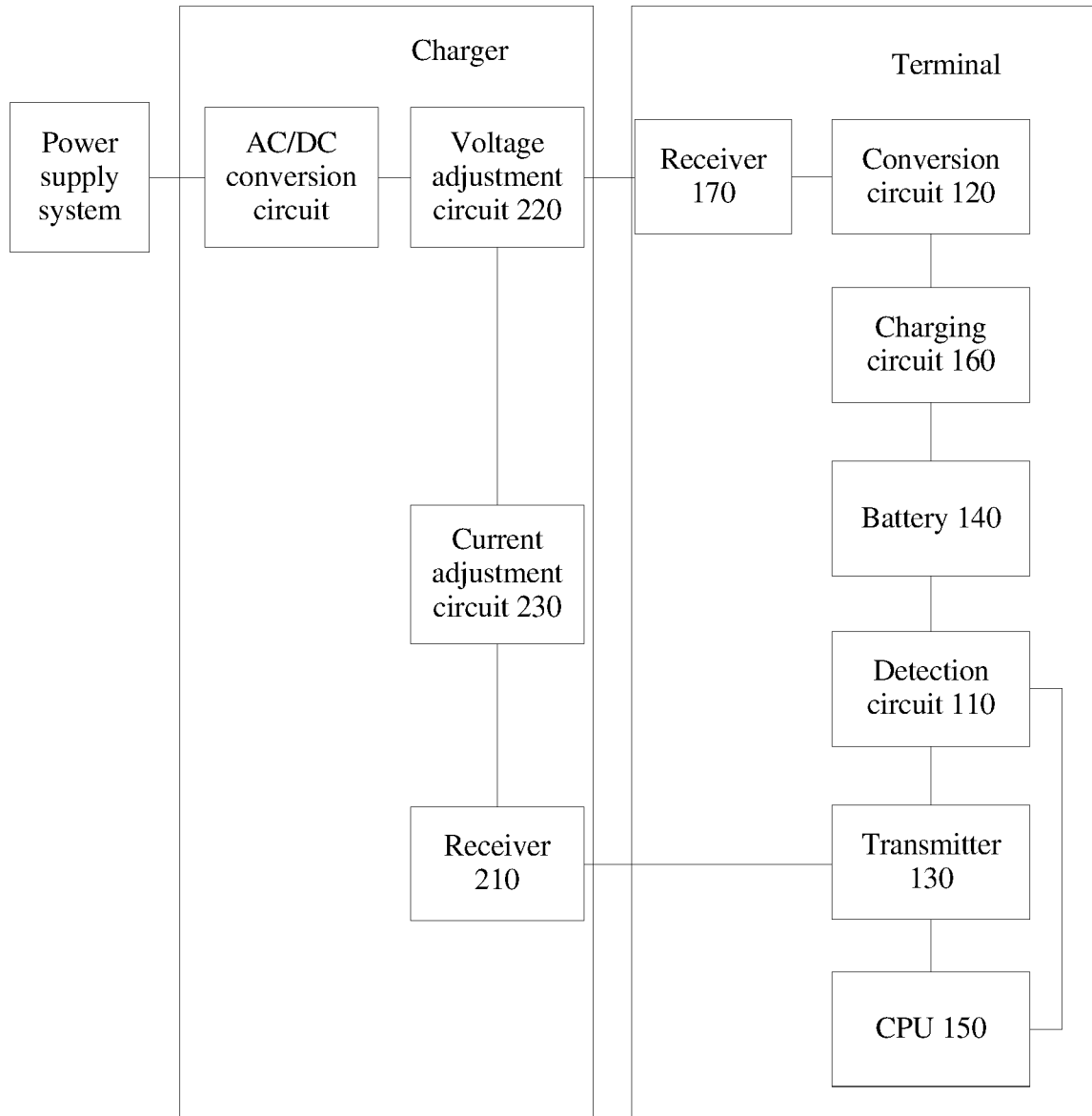


FIG. 3

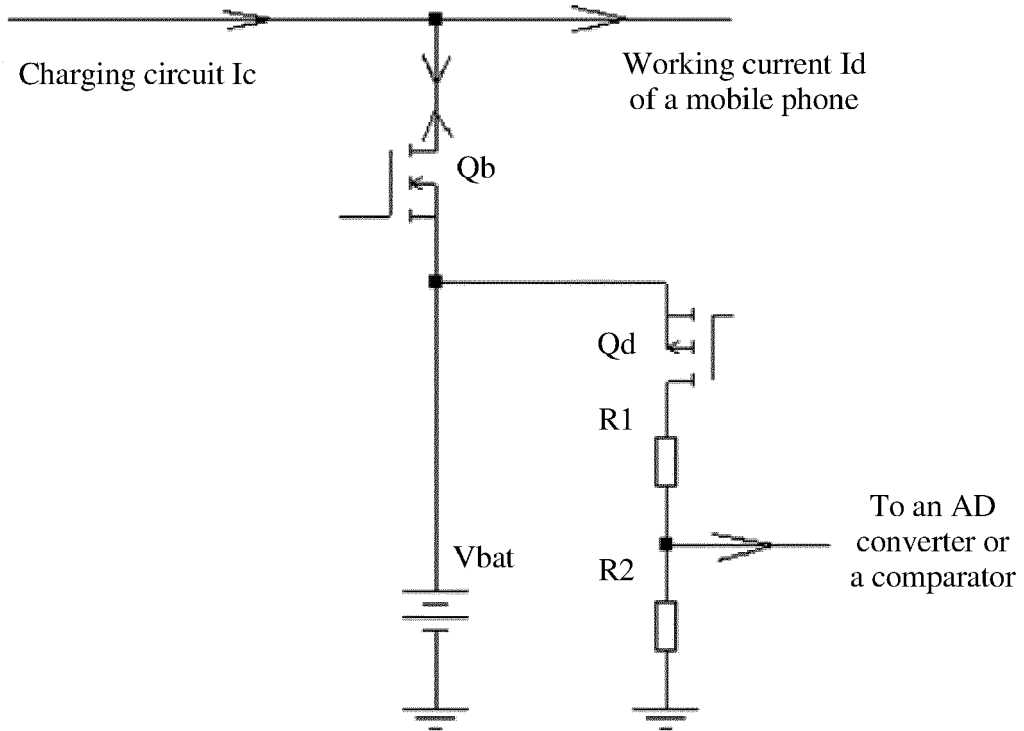


FIG. 3a

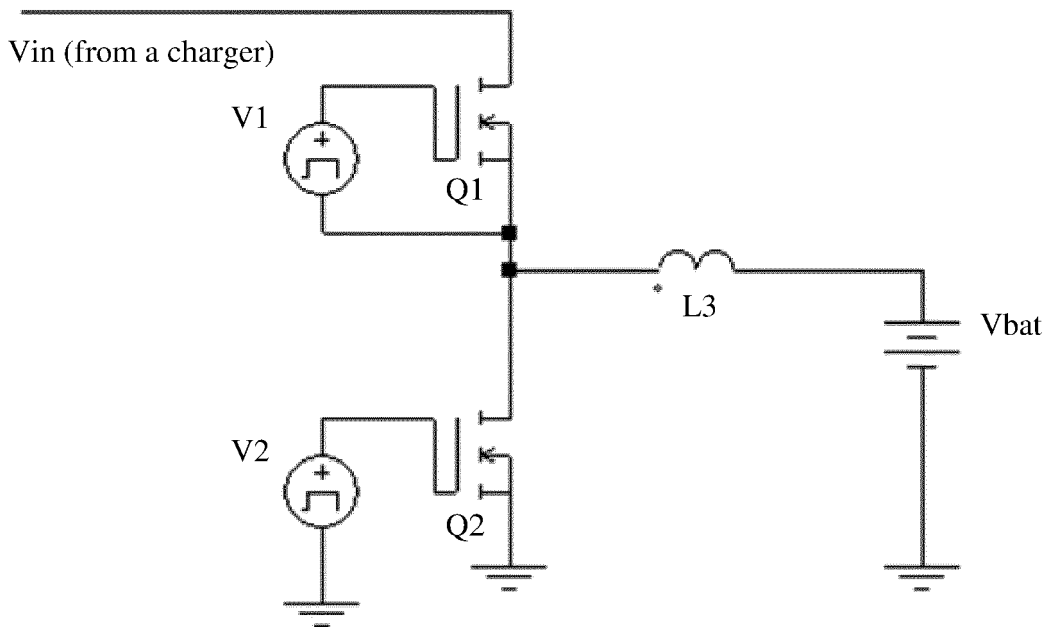


FIG. 4

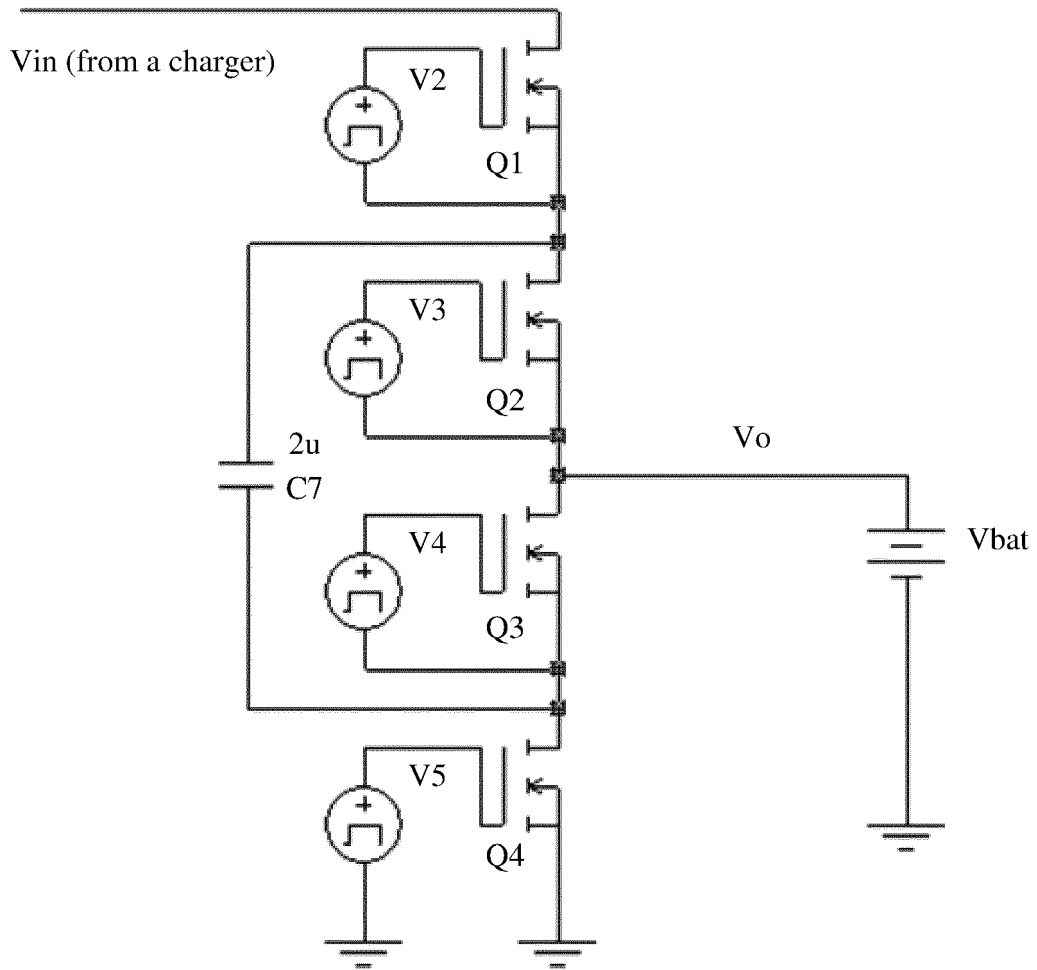


FIG. 5

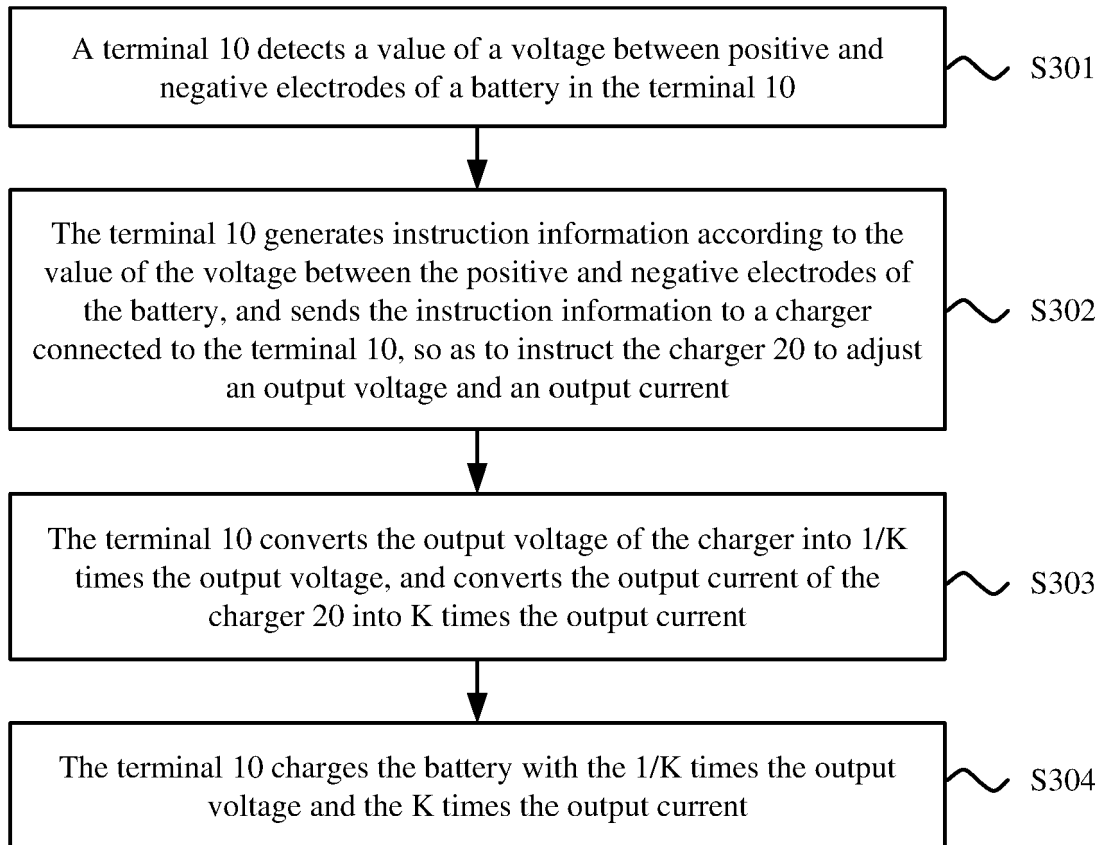


FIG. 6

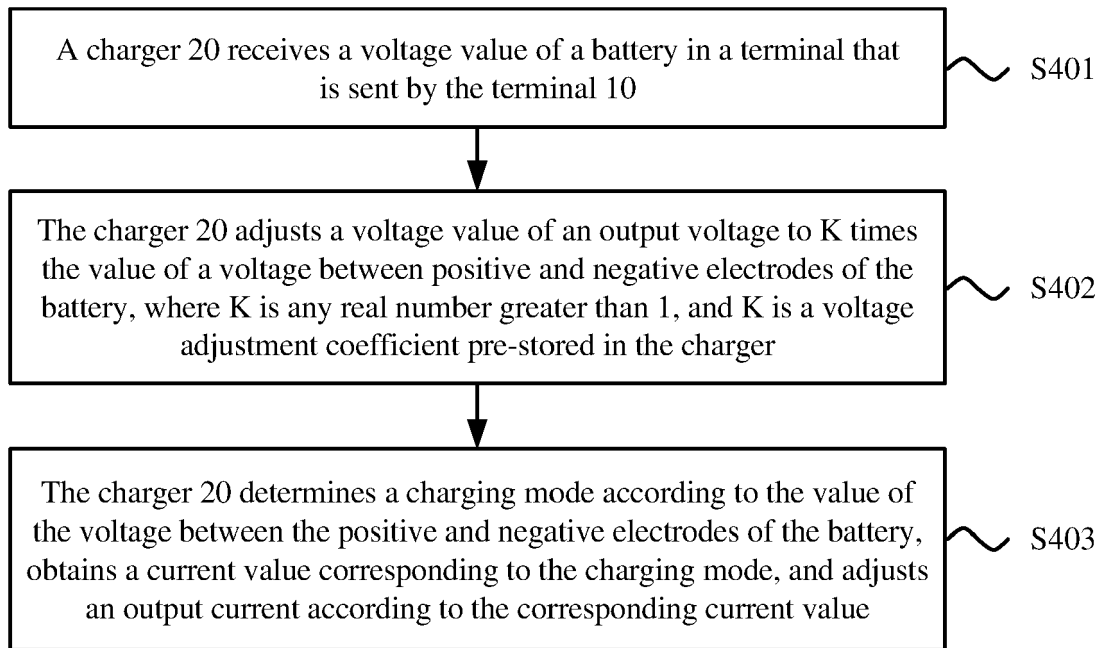


FIG. 7

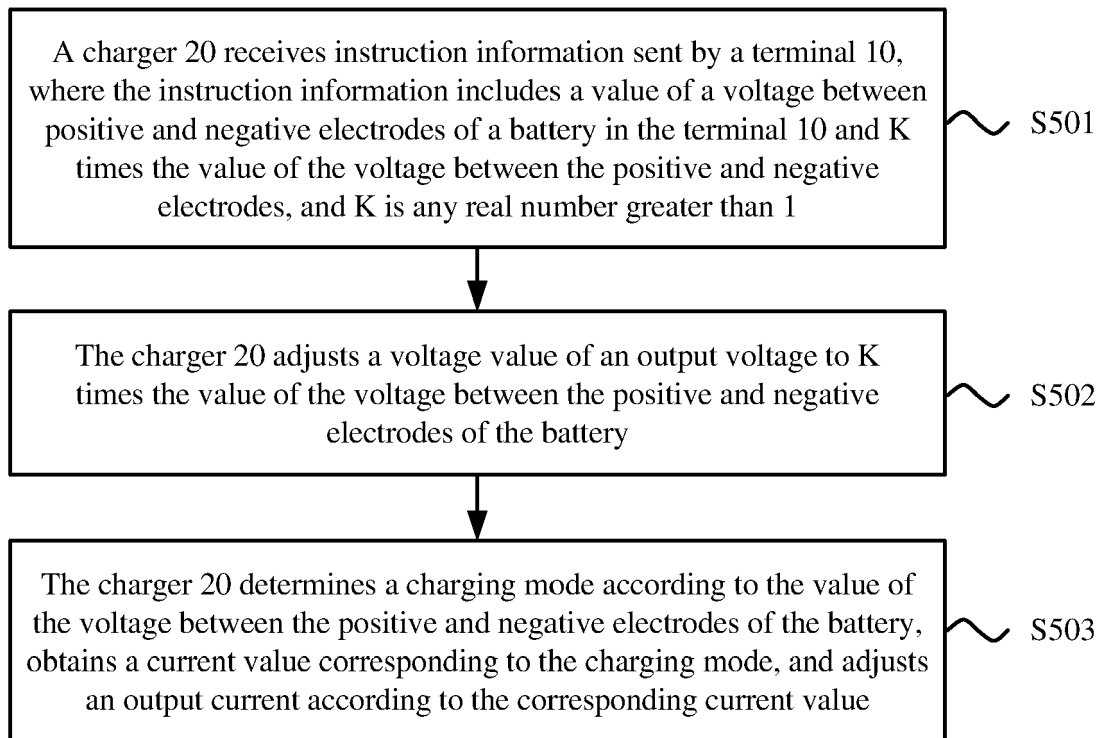


FIG. 8

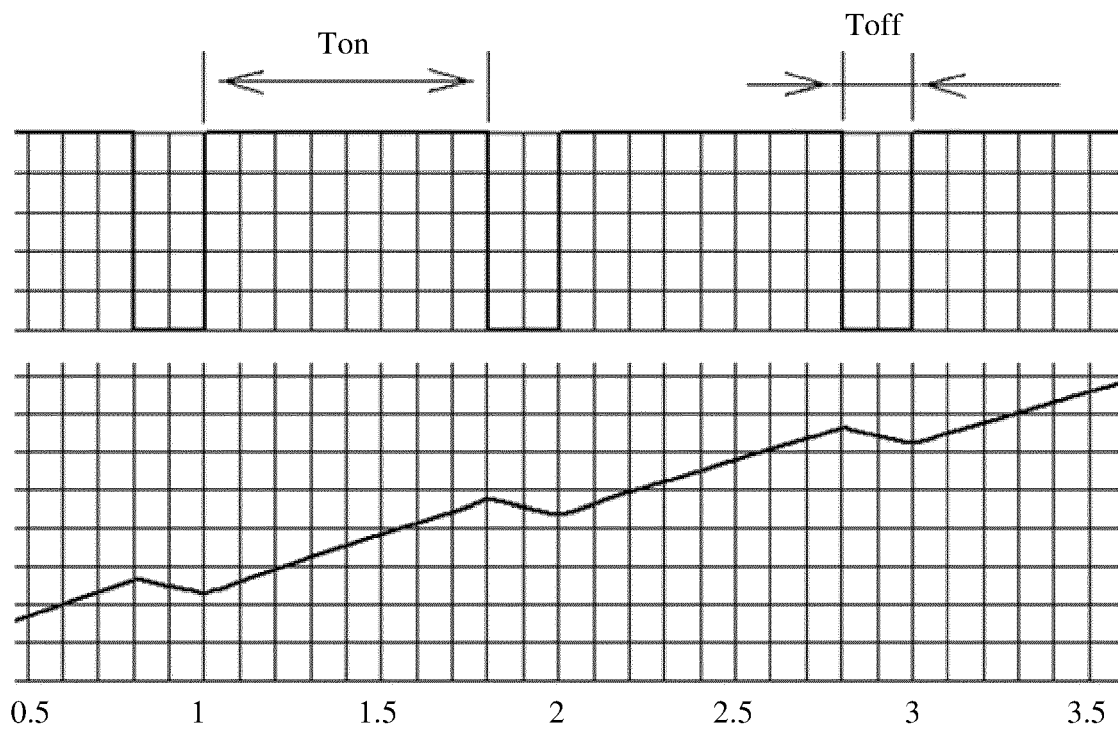


FIG. 9



EUROPEAN SEARCH REPORT

Application Number
EP 23 15 7715

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2015/113349 A1 (GUANGDONG OPPO MOBILE TELECOMM [CN]) 6 August 2015 (2015-08-06) * paragraphs [0010] - [0053]; figures 1-12 * & EP 3 101 758 A1 (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD [CN]) 7 December 2016 (2016-12-07) -----	1-13	INV. H02J7/00
A	WO 2015/113333 A1 (GUANGDONG OPPO MOBILE TELECOMM [CN]) 6 August 2015 (2015-08-06) * the whole document * & EP 3 101 752 A1 (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP LTD [CN]) 7 December 2016 (2016-12-07) -----	1-13	
A	EP 2 942 853 A1 (HUAWEI DEVICE CO LTD [CN]) 11 November 2015 (2015-11-11) * the whole document * -----	1-13	
A	US 2014/300321 A1 (KIM CHULKWI [KR] ET AL) 9 October 2014 (2014-10-09) * the whole document * -----	1-13	TECHNICAL FIELDS SEARCHED (IPC) H02J
A	US 2009/174366 A1 (AHMAD BAHER A [US] ET AL) 9 July 2009 (2009-07-09) * the whole document * -----	1-13	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 May 2023	Examiner Hunckler, José
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03:82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 23 15 7715

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-05-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015113349 A1	06-08-2015	AU 2014381139 A1	18-08-2016
		BR 112016017532 A2	08-08-2017
		CA 2938139 A1	06-08-2015
		CL 2016001916 A1	31-03-2017
		CN 104810877 A	29-07-2015
		CN 106532884 A	22-03-2017
		DK 3101758 T3	18-03-2019
		DK 3462568 T3	25-11-2019
		EP 3101758 A1	07-12-2016
		EP 3462568 A1	03-04-2019
		ES 2715395 T3	04-06-2019
		ES 2761003 T3	18-05-2020
		HU E042870 T2	29-07-2019
		JP 6239776 B2	29-11-2017
		JP 6325163 B2	16-05-2018
		JP 2017506053 A	23-02-2017
		JP 2018061428 A	12-04-2018
		KR 20160135710 A	28-11-2016
		KR 20190111159 A	01-10-2019
		MA 39302 A1	31-12-2018
		PH 12016501487 A1	22-08-2016
		PL 3101758 T3	31-05-2019
		PT 3101758 T	06-02-2019
		PT 3462568 T	22-11-2019
		SG 11201606227T A	29-09-2016
		US 2016352132 A1	01-12-2016
		US 2017250555 A1	31-08-2017
		WO 2015113349 A1	06-08-2015
		ZA 201605311 B	25-09-2019
WO 2015113333 A1	06-08-2015	CN 104810873 A	29-07-2015
		CN 108134432 A	08-06-2018
		EP 3101752 A1	07-12-2016
		EP 3547492 A1	02-10-2019
		ES 2740900 T3	07-02-2020
		ES 2809159 T3	03-03-2021
		US 2016344218 A1	24-11-2016
		US 2018241238 A1	23-08-2018
		US 2019123573 A1	25-04-2019
		US 2019222049 A1	18-07-2019
		US 2022140634 A1	05-05-2022
		WO 2015113333 A1	06-08-2015
EP 2942853 A1	11-11-2015	AU 2014207189 A1	07-01-2016
		AU 2017201704 A1	30-03-2017
		CA 2908514 A1	24-07-2014

EPC FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

55

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 23 15 7715

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-05-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		CN 103107575 A	15-05-2013
		EP 2942853 A1	11-11-2015
		EP 3432441 A1	23-01-2019
		ES 2688581 T3	05-11-2018
		JP 6452162 B2	16-01-2019
		JP 6516380 B2	22-05-2019
		JP 2016509463 A	24-03-2016
		JP 2017192300 A	19-10-2017
		KR 20150106452 A	21-09-2015
		KR 20170039760 A	11-04-2017
		RU 2666776 C1	12-09-2018
		RU 2015147645 A	12-05-2017
		SG 10201702163V A	30-05-2017
		SG 11201508298W A	27-11-2015
		US 2015326046 A1	12-11-2015
		US 2018254645 A1	06-09-2018
		US 2018254646 A1	06-09-2018
		WO 2014110995 A1	24-07-2014
		ZA 201507519 B	30-03-2022
		ZA 201907215 B	23-12-2020

US 2014300321 A1	09-10-2014	KR 20140120699 A	14-10-2014
		US 2014300321 A1	09-10-2014

US 2009174366 A1	09-07-2009	US 2009174366 A1	09-07-2009
		WO 2009089230 A2	16-07-2009

EPC FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82